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G. B. Airy, Esq., President, in the Chair.

Lieut.-Col. Patrick Stewart, R.E., 8 Lower Belgrave Street, and
J. Wm. Harris, Esq. M.R.C.S.L., Southernhay, Exeter,
were balloted for and duly elected Fellows of the Society.

Determination of the Sun's Mean Horizontal Equatoreal Parallax, from a Comparison of Corresponding Observations of N.P.D. of Mars and Stars, made at the Royal Observatory, Greenwich, and the Government Observatory, Williamstown, Victoria, Australia, during the Opposition of 1862. By E. J. Stone, Esq.

In his Tables of *Mars*, published in the *Annals of the Imperial Observatory*, Paris, 1861, M. Le Verrier remarks that it is impossible to reconcile the observations of *Mars* with theory without attributing to the perihelion a motion greater than any which can be obtained, except by a sensible increase of the received planetary masses; that the necessary agreement between theory and observation could be obtained by increasing the received value of the mass of the Earth in proportion to the Sun's mass, by not less than a tenth part, but that such an increase in the received value of the Earth's mass would necessitate a corresponding increase in the received value of the Sun's mean equatoreal horizontal parallax of a thirtieth part.

M. Le Verrier deduced the same result from a discussion of the latitudes and the motion of the node of *Venus*. The dif-

ficulties raised in the theory of *Mercury*, although not removed, were slightly diminished by the same increase of the Earth's mass.

In his Solar Tables, M. Le Verrier has adopted the value $8''{\cdot}95$ for the mean equatoreal horizontal solar parallax; this value was obtained by determining from observation the coefficient of the lunar equation and assuming the mean lunar parallax and data furnished by the theories of Precession and Nutation.

The way in which M. Le Verrier has thus evolved from the theories of *Venus*, the Earth, and *Mars*, the necessity of a value of the mean solar parallax much greater than the usually received value $8''{\cdot}57$, and not differing greatly from $8''{\cdot}95$, must render it extremely probable that the true value of the Sun's mean parallax does not differ greatly from that quantity.

It is the object of the present paper to lay before the Society a redetermination of the Sun's mean equatoreal horizontal parallax.

Some time since Robert L. S. Ellery, Esq., the Director of the Government Observatory, Williamstown, Victoria, Australia (Longitude E. $9^{h}{\cdot}39^{m}\ 39^{s}{\cdot}3$, Latitude S. $37^{\circ}\ 52'\ 6''{\cdot}6$), forwarded to the Astronomer Royal a fine series of meridian declination observations of *Mars*, made during the period extending from 1862, August 20, to the middle of the following November. These observations the Astronomer Royal has kindly placed in my hands for comparison with the corresponding Greenwich observations. I have thus deduced 22 independent determinations of the Sun's mean solar parallax.

The method of reduction pursued has been as follows:—The North Polar Distances of *Mars* at the Greenwich and Williamstown transits, and the geocentric distances of the planet, have been obtained, where necessary, by interpolation from the *Nautical Almanac*. The Greenwich observations were then compared with the tables; and from the system of errors thus exhibited a curve was roughly drawn to represent the change of error: the only use of this curve was to determine the small change of error of tabular places between the transits of *Mars* over the meridians of Williamstown and Greenwich.

The factors of the Sun's mean horizontal equatoreal parallax in the expressions for the parallax in declination were then calculated, using the Astronomer Royal's value of the ratio of the principal axes of the earth, viz. $\frac{299}{300}$; and the observations of *Mars* compared with the same stars at Greenwich and Williamstown. In weighting the observations, I have considered the probable error of an observation of the centre of *Mars*, deduced from observations of the two limbs, equal to the probable error of a good star observation: the weights are the strict theoretical weights, and I have considered all

observations as equally good, unless the observer has expressed himself dissatisfied with the observation at the time of making it. All the Greenwich observations that could be combined with observations at Williamstown, without trusting to the interpolation of change of tabular error for more than two days, and without using different stars of comparison at the two stations, have been so combined, and the results are given. The following are the separate results:—

1862.	Mean Horizontal Equatoreal Parallax.	Weight.	1862.	Mean Horizontal Equatoreal Parallax.	Weight.
	″			″	
Aug. 25	9·240	3·1329	Oct. 3	9·024	2·9241
27	9·646	3·4969	8	8·962	2·8561
28	9·416	2·2201	9	9·024	2·8224
Sept. 3	8·868	1·7689	11	8·748	2·7556
10	9·161	4·2436	18	8·497	0·5329
11	8·756	4·0000	22	8·929	2·4025
16	8·844	3·7249	24	8·559	1·4884
17	9·148	2·8224	29	8·708	3·6100
21 & 22	8·684	4·3264	Nov. 3	8·620	0·4356
23	9·074	4·3681	9 & 10	8·932	2·2201
25	9·052	2·9584	12	9·006	1·5876

The mean result is 8″·932, and if we assume the probable error of a single observation = 0″·25, the probable error of the above result would be 0″·032.

The comparison of the Greenwich and Williamstown observations, therefore, leads to the value 8″·932 ± 0″·032 for the Sun's mean horizontal equatoreal parallax,— a value differing but slightly from the value assumed by M. Le Verrier in his Solar Tables.

M. Otto von Struve, Associate of the Society, gave an account of a remarkable local deviation in the direction of gravity, which has lately been observed in Russia. It is the more remarkable from its occurring in a country which is totally free from mountains, and which, though slightly undulating, may be described as a very level plain country.

On computing, upon the best elements for the figure of the earth, the longitudes and latitudes of the points in the Russian triangulation, it was found that the observed co-latitude of the Observatory of Moscow was about 8″ greater than that given by the geodetic connexion with other well-determined points of the survey. To put this beyond doubt, it was compared with numerous triangulation-stations in its neighbourhood, and the

results, with only such discordances as may always be expected, were all of the same kind. The high character of Professor Schweizer, the observer at Moscow, placed the validity of the astronomical determination beyond all suspicion. Professor Schweizer, then, with such assistance as he could command, repeated the observations at numerous points in the vicinity of Moscow. The following is the general result:

Upon the map below there will be remarked three somewhat irregular lines, nearly in the direction E.N.E. and W.S.W. Along the central line the observed co-latitudes agreed sensibly with the geodetic co-latitudes. To the north of that central line, for a considerable distance, the observed co-latitudes are too great, and to the south of that central line they are too small. The upper and lower lines show the places of maximum discordance; the upper line passes sensibly through the Observatory of Moscow. The disturbances appear to have been traced to about one degree of longitude on each side, east and west, where their magnitudes are reduced to about one-half of those in the neighbourhood of Moscow.

The amount of disturbance near Moscow, in relation to the distance of a place from the central line, is nearly as follows:—

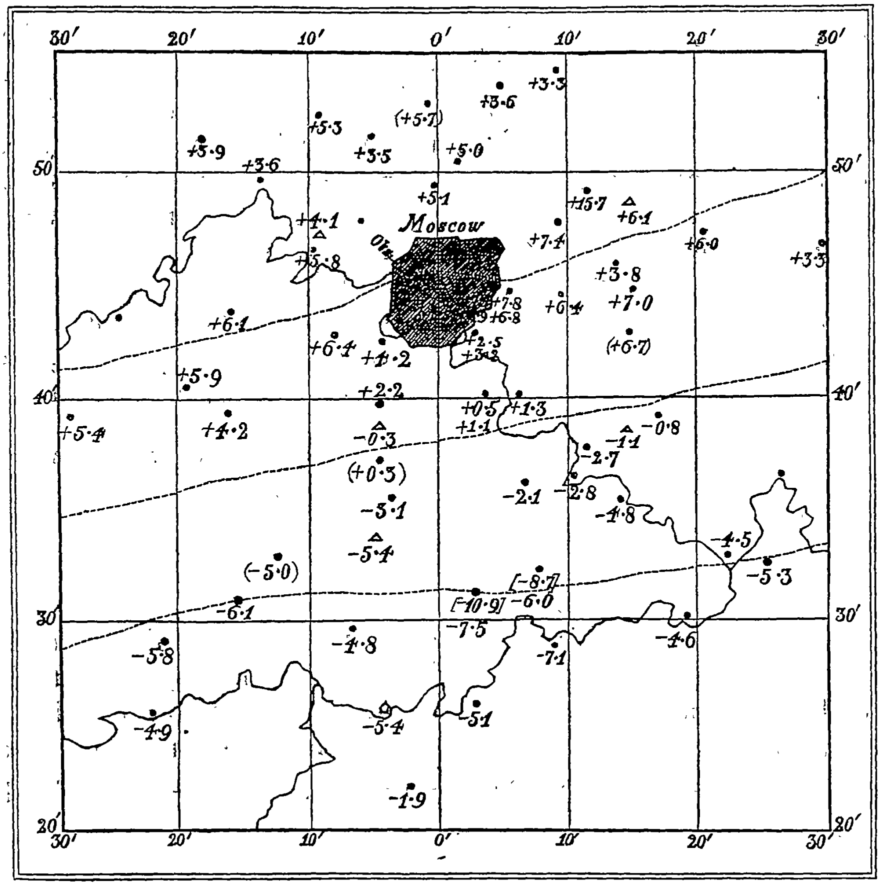
At distance	0	...	disturbance = 0
	3·8 versts	= 2·5 English miles ...	2″·22
	12 ...	= 8 ...	7·80
	20 ...	= 13 ...	5·15
	26·59 ...	= 18 ...	2·10
	34 ...	= 23 ...	0

Its magnitude is sensibly the same, but with opposite signs, at equal distances north and south of the central line. The deviation at distances not exceeding 8 miles from the central line, is not less than $\frac{1}{60}$th part of the angle made by the verticals. Its sign is that corresponding to a deficiency of matter beneath the central line; and it does not apparently admit of explanation by any other supposition, as by an excess of density of the earth's crust in two places, one north and the other south, because beyond the limits above stated there is no trace of sensible disturbance.

According to Professor Schweizer's calculations, the volume of deficiency of matter, of the same density as the earth's crust, must be 1·2 cubic German geographical miles (the German geographical mile is $\frac{1}{15}$th of a mean degree of latitude). This supposes that the deficiency is at no great depth below the central line. If the density of the earth's crust, in that part, be only partially diminished, the volume of matter so affected must be increased in a corresponding proportion.

M. O. Struve, struck with the importance of these observations, and with the probable advantage of pursuing them

further, has applied for, and has obtained, from the Imperial Government, the means of enabling Professor Schweizer to examine the local disturbances at numerous points, in a district of considerable extent, connected with the general survey by a secondary triangulation. The small map below embraces but a portion of the country to be thus examined. It is intended that the comparison of observed and geodetic co-latitudes shall



The shaded space is the city of Moscow. The observatory is in its upper left-hand corner.

The figures at other stations denote the excess of observed co-latitudes, in seconds. Those inclosed in brackets are less certain.

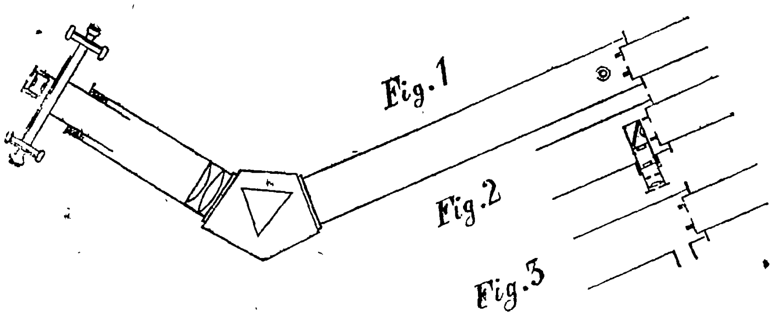
be extended, especially to the east and west, until the discrepancies disappear. When these limits are ascertained, it is intended, on Mr. Struve's suggestion, that longitudes and azimuths shall be observed at numerous stations. The elevation of different points, and the general form of the district, will also be ascertained by levelling, in order to eliminate the very small effects which may be produced by the inequalities of the surface. And pendulum-experiments are to be made, for ascertaining the effect of the disturbing cause on the force of gravity.

The extension of the survey is already begun by the Imperial General-Staff (Etat-Major). And for the other operations, Professor Schweizer will receive all the assistance which the influence of Russian scientific bodies can obtain.

The President remarked on this interesting communication, that it was one of great value, not merely for the importance of the results obtained, but also as an instance of extraordinary combination of different powers of different officers, directed each in the most advantageous way. Numerous instances had occurred of anomalies in the direction of gravity, but there had been few instances in which a superior officer had at once perceived, as Mr. Struve had done, the importance of the phenomena thus revealed, and the advantage of tracing them further, not only by extension over a larger area, but also by the introduction of other classes of observation; in which application for further powers had been made; in which the Government had with so much liberality responded to the call; and in which, by the zeal and ability of the officer immediately intrusted, the results, as far as they had been pursued, had been so happily worked out, and results of even greater importance were in prospect.

G. B. A.

The Astronomer Royal gave an oral account, illustrated by drawings, of the apparatus which had been prepared at the Royal Observatory, Greenwich, for the observation of the spectra of stars, and of some of the principal results obtained. In the drawing below, the first figure represents the entire ap-



paratus, in section; the second and third figures represent the right-hand portion of the apparatus in a section through the axis of the long tube, but at right angles to the former section.

In fig. 1, the smaller tube at the right-hand is for insertion in the socket upon the breech-piece of the telescope of the great equatoreal. To carry the apparatus steadily, (great accuracy of position is not needed) a temporary frame is screwed to the

sides of the telescope tube. The right-hand tube is thrust into the socket so far that the image of the star is formed in the moderately small hole in the inner end of that smaller tube. The pencil of light from the object-glass, which has converged to form the image of the star, then diverges and falls in a wide and divergent state upon the prism; after emergence it is received on a combination of lenses, which causes the pencils for the different colours to converge. It is seen thus that a spectrum may be formed at the place of the micrometer; it is necessary now to explain how breadth is given to the spectrum.

For this purpose the prism is not placed in the position of minimum deviation, or the position in which the angles of incidence and emergence are equal. It is so inclined that the angle of emergence is greater than the angle of incidence. With this arrangement, the change in the degree of divergence of the extreme rays of the pencil is different as regards (on the one hand) rays in the upper and lower parts of the pencil, or in the plane of the paper, and (on the other hand) rays in the plane perpendicular to the paper. The difference is such that, when after passing through the lenses the former have converged so as to form a pure spectrum at the place of the micrometer, the latter have passed convergence, and therefore the spectrum has breadth. The position of the prism, which gave a convenient breadth to the spectrum, was determined by trial. It is necessary to remark that the lenses must not be achromatic; they are in fact made of dispersive flint glass; if achromatic, the spectrum would have been formed in a plane inclined to the plane of the micrometer. The whole of these peculiarities were calculated numerically on geometrical theory before the construction was attempted.

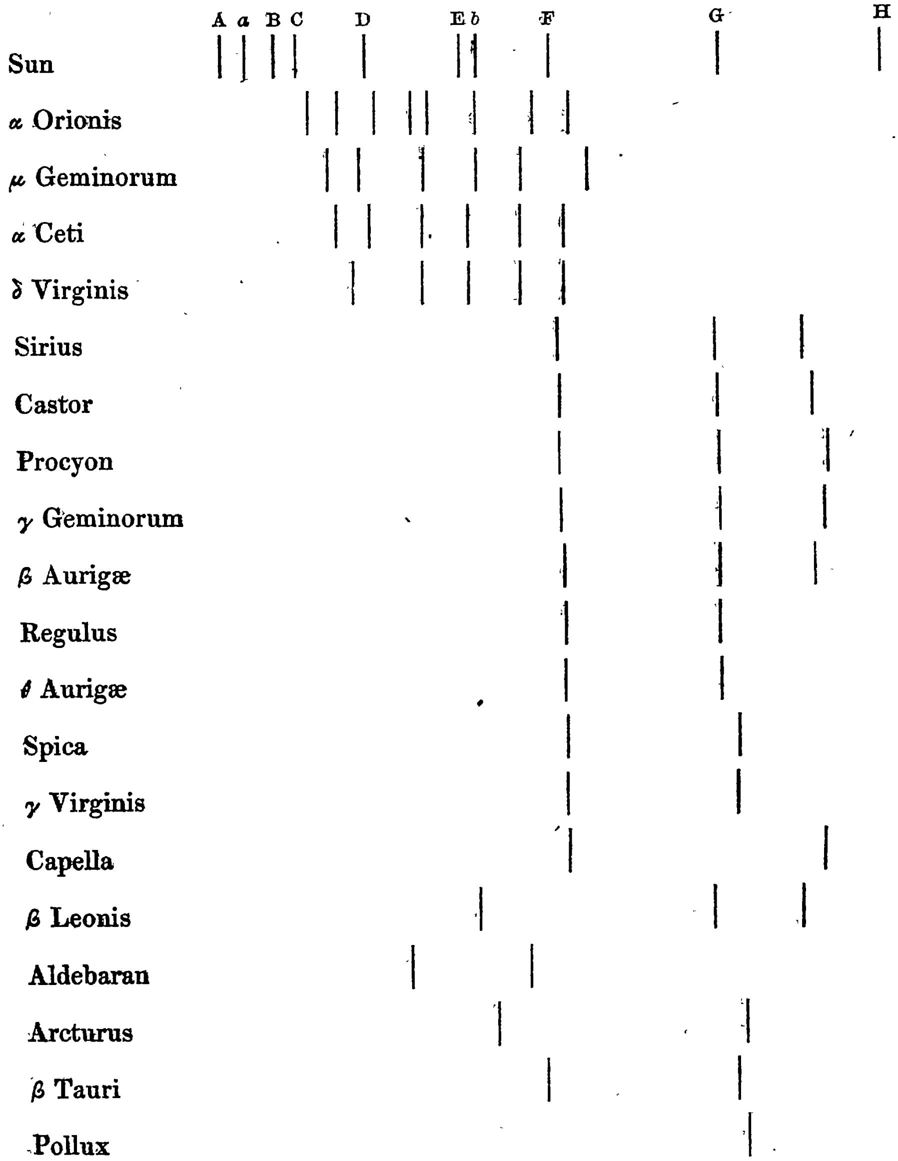
This principle may be regarded at present as experimental. In simplicity of construction it is much superior to the principle of causing the pencils which pass through the prism to consist of parallel rays, which requires the use of two achromatic object-glasses and one cylindrical lens; but it is not yet certain whether or not it defines the spectral lines with equal sharpness.

It is necessary now to explain how reference is made to the lines of the solar spectrum. In fig. 1, near the right-hand extremity of the large tube, a small circle may be seen. This is a view (not properly in section) of a small socket, which in fig. 3, lower side, may be seen empty; and which in fig. 2 contains a small eye-piece. It is thus used. A tube, containing at its end a very small hole (possibly $\frac{1}{500}$ inch in diameter) is thrust, in a definite position, into the right-hand tube of fig. 1, till the small hole is in the focal plane of the telescope-image. In this state the telescope is turned to the sun; the small hole represents a star of solar matter; and its spectrum may be observed and measured. An eyepiece with diagonal reflector, and carrying a wire in its focus, is thrust into the small socket, as in fig. 2, and the position of the solar hole with

reference to the wire is carefully observed. Then, when a star is to be observed, the small eyepiece is thrust in, the telescope is moved till the star's image has the same position in regard to the wire which the solar hole had, and then it is certain that the star occupies precisely the place of the solar hole; then the small eyepiece is withdrawn, and the spectrum is observed and measures are made with the micrometer.

For reading the comb of the micrometer there is an annular reflector to illuminate the field, not shown in the drawing.

The following sketch exhibits lines whose positions have been measured by Mr. Carpenter; numerous lines have been seen but not measured.



On this sketch Mr. Carpenter remarks:—

This diagram is only intended to show the positions of the

lines; no attempt has been made to illustrate their characters or their different intensities. The stellar lines are generally nebulous, resembling the solar line H; in the first four stars on the diagram they are, however, much more diffused on the side opposite to the red end of the spectrum.

Since these observations were communicated to the Society two more lines have been detected in the spectrum of *Arcturus*; one coincident with solar D, the other between it and solar C.

G. B. A.

Lines in the Solar Spectrum, as observed in the Balloon Ascent, 31st March last. By J. Glaisher, Esq. F.R.S.

The Astronomer Royal lent me the same apparatus as was used by Professor Smyth on the Peak of Teneriffe, for the purpose of observing the black lines in the spectrum. It consists of a prism, a fine adjustable slit placed in the focus of an object-glass of 14 inches focal length, and a telescope of the same length directed to the prism. No angular measure was contemplated, only eye observations and comparison of differences in the spectrum seen on the earth and at different distances from it in the course of the journey.

On the earth before leaving, a careful examination of the sky spectrum showed B as the limit of the red end, and some distance beyond G as that of the violet end, and all the principal lines.

The balloon left the earth on March 31, at a quarter past four P.M. At the height of half-a-mile the spectrum showed a general correspondence with that seen before starting, but I thought that G was less distinct and B was certainly less so.

At the height of a mile the spectrum was bright, but was shorter both at the red and violet ends, G was quite the limit, B was not visible, and C was doubtful.

At the height of two miles G was entirely lost, I could see F and D, but not beyond.

At the height of three miles the spectrum was very short, I could see a little beyond D to E, F was quite lost.

At the height of four miles I could see a little yellow tinge, but no lines.

At the height of four and a half miles I had no spectrum at all, even with a very open slit.

All those spectra were from the sky at an elevation of 60°; as far as time permitted I looked at a horizontal spectrum, and I did not see any marked difference between it and the spectrum at the higher elevation, at the same time. The general results